

Uncertainties Related to Cosine and Azimuthal Errors of Version 2 McMurdo Data

Uncertainties related to cosine and azimuthal errors of the SUV-100 spectroradiometer at McMurdo were calculated according to the procedure outlined in Sections S3.2 and S3.3 of the work by *Bernhard et al.* [2004]. These uncertainties also depend on prevailing atmospheric conditions, surface albedo, and solar zenith angle (SZA). These difference and the fact that cosine and azimuthal errors of the instruments deployed at South Pole and McMurdo are slightly different, required some modifications to the various parameters used by *Bernhard et al.* [2004]. These modifications are described below and resulting uncertainties are summarized in Table 1.

Nomenclature (See *Bernhard et al.* [2004] for further information)

SZA	Solar zenith angle in degrees
λ	Wavelength in nm
f_B	Cosine error
$u_R(f_B)$	Relative uncertainty of cosine error
f_D	Diffuse cosine error, defined as the error in measuring isotropic radiance
$u_R(f_D)$	Relative uncertainty of f_D
R	Ratio of irradiance from the direct solar beam on a horizontal surface to global irradiance
$u_R(f_R)$	Relative uncertainty of R
f_G	Ratio of measured global irradiance affected by the cosine error to true global irradiance
$u_R(f_G)$	Relative uncertainty of f_G
τ	Cloud optical depth at 450 nm
τ_A	Aerosol optical depth at 500 nm

Contributions of parameters

The relative uncertainty of the cosine error $u_R(f_B)$ was estimated from variations of the cosine error f_B in different years. For Volumes 1-9 (1989-1999), $u_R(f_B)$ was set to 0.5% for SZA<40°; 1.0% for 40°<SZA<60°; 1.5% for SZA=70°; 2.5% for SZA=80°; and 4% for SZA=85°. For Volumes 10-13 (2000-2004), $u_R(f_B)$ was set to <1.0% for SZA<20°; <1.5% for SZA<60°; 2.5% for SZA=70°; 6% for SZA=80°; and 11% for SZA=85°.

The uncertainty $u(R)$ of the direct/global ratio $R(\lambda)$ under clear skies was estimated from the difference of $R(\lambda)$ calculated for aerosol optical depths τ_A of 0.015, 0.025 and 0.035. The choice of this range considers that model estimates of $R(\lambda)$ were based on $\tau_A = 0.025$, whereas measured background aerosol optical depth at the McMurdo varies between 0.025 ± 0.010 [Shaw, 1982]. Based on these considerations, $u_R(R)$ was calculated to 1.5% at SZA=55°, 2.2% at SZA=70°, 4.0% at SZA=80°, and 8.3% at SZA=85°. These values were also applied to cloudy conditions as the value of the relative uncertainty $u_R(R)$ has little impact on the overall uncertainty $u(f_G)$ when clouds reduce the direct contribution $R(\lambda)$ to near zero.

The uncertainty $u_R(f_D)$, which is mostly caused by the assumption that sky radiance is isotropic, was recalculated by taking prevailing atmospheric conditions and surface albedo into account.

Uncertainties due to residual azimuthal errors in corrected data were quantified by analyzing the amplitude of periodic diurnal variations in the ratio of measurement and model during clear-sky periods. Uncertainties vary between 0.4% and 5.2% depending on wavelength and volume, and are compiled in Table 2. These uncertainties disappear under cloud conditions.

References

[Bernhard, G., C.R. Booth, and J.C. Ebrahimian \(2004\), Version 2 data of the National Science Foundation's Ultraviolet Radiation Monitoring Network: South Pole, *J. Geophys. Res.*, 109, D21207, doi:10.1029/2004JD004937.](#)

Shaw, G.E. (1982), Atmospheric turbidity in the polar regions, *J. Appl. Meteorol.*, 21, 1080-1088.

Table 1. Standard Uncertainty (k=1) Caused by Cosine Error as a Function of SZA, Wavelength λ and Cloud Optical Depth τ .

SZA [deg]	λ [nm]	f_B	f_D	R	$\tau = 0$		$\tau = 0.2$		$\tau = 1.0$		$\tau = ?$		
					f_G	$u_R(f_G)$	R	f_G	$u_R(f_G)$	R	f_G	$u_R(f_G)$	$u_R(f_G)$
<i>Volume 6B (applicable to Volumes 1-9)</i>													
60	310	0.98	0.986	0.17	0.985	0.5%	0.11	0.985	0.5%	0.02	0.985	0.6%	0.8%
60	400	0.98	0.986	0.50	0.983	0.6%	0.34	0.984	0.5%	0.07	0.985	0.6%	0.9%
60	600	0.98	0.986	0.86	0.982	0.9%	0.58	0.983	0.6%	0.12	0.985	0.6%	1.1%
70	310	0.99	0.986	0.07	0.986	0.5%	0.04	0.986	0.6%	0.00	0.986	0.6%	0.8%
70	400	0.99	0.986	0.40	0.986	0.7%	0.23	0.986	0.6%	0.02	0.986	0.6%	0.9%
70	600	0.99	0.986	0.82	0.987	1.2%	0.48	0.986	0.8%	0.05	0.986	0.6%	1.4%
80	310	1.00	0.986	0.00	0.986	0.6%	0.00	0.986	0.6%	0.00	0.986	0.6%	0.8%
80	400	1.00	0.986	0.18	0.988	0.7%	0.06	0.986	0.6%	0.00	0.986	0.6%	0.9%
80	600	1.00	0.986	0.71	0.996	1.8%	0.27	0.989	0.9%	0.00	0.986	0.6%	2.0%
85	310	1.00	0.986	0.00	0.986	0.6%	0.00	0.986	0.6%	0.00	0.986	0.6%	0.8%
85	400	1.00	0.986	0.03	0.986	0.6%	0.00	0.986	0.6%	0.00	0.986	0.6%	0.9%
85	600	1.00	0.986	0.53	0.996	2.2%	0.09	0.987	0.8%	0.00	0.986	0.6%	2.3%
<i>Volume 11 (applicable to Volumes 10-13)</i>													
60	310	0.96	0.955	0.17	0.956	0.7%	0.11	0.955	0.7%	0.02	0.955	0.7%	1.0%
60	400	0.96	0.955	0.50	0.958	0.9%	0.34	0.957	0.8%	0.07	0.955	0.8%	1.4%
60	600	0.96	0.955	0.86	0.960	1.3%	0.58	0.958	1.0%	0.12	0.955	0.9%	2.2%
70	310	0.89	0.955	0.07	0.950	0.7%	0.04	0.952	0.7%	0.00	0.954	0.7%	1.0%
70	400	0.89	0.955	0.40	0.929	1.2%	0.23	0.940	1.0%	0.02	0.953	0.9%	1.8%
70	600	0.89	0.955	0.82	0.901	2.1%	0.48	0.923	1.6%	0.05	0.951	1.2%	3.3%
80	310	0.72	0.955	0.00	0.954	0.7%	0.00	0.954	0.7%	0.00	0.955	0.7%	1.0%
80	400	0.72	0.955	0.18	0.913	1.3%	0.06	0.940	1.1%	0.00	0.954	0.8%	2.1%
80	600	0.72	0.955	0.71	0.790	4.1%	0.27	0.893	2.6%	0.00	0.954	1.3%	7.0%
85	310	0.51	0.955	0.00	0.955	0.7%	0.00	0.955	0.7%	0.00	0.955	0.7%	1.0%
85	400	0.51	0.955	0.03	0.940	1.0%	0.00	0.952	1.0%	0.00	0.955	0.8%	1.5%
85	600	0.51	0.955	0.53	0.720	5.1%	0.09	0.914	2.8%	0.00	0.955	1.1%	9.6%

Table 2. Standard Uncertainty (k=1) of Azimuthal Errors.

Volume	Period	Relative Uncertainty in %		
		330 nm	400 nm	590 nm
1	Dec 89 - Feb 91	1.0%	2.3%	3.4%
2	Feb 91 - Dec 91	? ^a	? ^a	? ^a
3	Dec 91 - Feb 93	1.4%	1.8%	3.0%
4	Feb 93 - Jan 94	0.5%	0.5%	2.7%
5	Jan 94 - Jan 95	0.7%	? ^b	? ^b
6A	Feb 95 - Jan 96	1.6%	2.3%	4.1%
6B	Jan 96 - Jan 97	1.4%	? ^b	? ^b
7	Jan 97 - Jan 98	1.1%	? ^b	? ^b
8	Jan 98 - Jan 99	1.4%	1.5%	2.1%
9	Jan 99 - Jan 00	0.7%	0.9%	2.7%
10	Feb 00 - Jan 01	0.4%	0.4%	2.5%
11	Jan 01 - Jan 02	0.5%	1.3%	5.3%
12	Jan 02 - Jan 03	0.7%	1.3%	2.5%
13	Jan 03 - Jan 04	1.5%	1.5%	1.6%
Average		1.0%	1.4%	3.0%
Standard Deviation		0.4%	0.7%	1.1%

^a Determination uncertain due to presence of volcanic aerosols

^b Determination uncertain due to possible shading of collector at SZA larger than 80°.